

RAIL GRADE SEPARATION TAYLORS ROAD - MELBOURNE - AUSTRALIA

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ABSTRACT

The Taylors Road rail underpass project eliminated a railway level crossing and a five-leg roundabout between Carbine Way and Kerrison Avenue in St. Albans, Melbourne's north-west. This AU\$54 million project constructed a new road underpass beneath rural-metropolitan rail lines improving safety for drivers, pedestrians, cyclists, public transport, rail users and eased traffic congestion.

The initial works commenced on-site in June 2006 with the relocation of a large number of services including a high pressure gas main, overhead and underground electricity and three water mains ranging from 300mm to 900mm in diameter in order to clear the way for the construction of the underpass. The design & construct contract was awarded in early 2007 with an expected completion date of early 2009.

The first stage of the main contract was to transfer traffic south of the roundabout to provide sufficient work area to construct the rail bridge. The bridge was constructed on two concrete beams east of the existing railway line, minimising disruption to the rail services. Once this 1200tonne rail bridge was completed, a 56 hour weekend occupation of the railway line was programmed for October 2007 to jack the bridge into its final position with replacement buses provided in lieu of the normal rail services. Following successful placement of the bridge that weekend, the next stage was to complete excavation under the rail bridge, construction of associated retaining walls and the road beneath including the a signalised intersection.

Road traffic was transferred under the bridge in September 2008 and the project was officially opened at the end of November 2008, ahead of time.

1. INTRODUCTION

The State of Victoria has 1,872 road level crossings on active rail lines ⁽¹⁾. There are around 200 railway level crossings in metropolitan Melbourne. ⁽²⁾

Taylors Road Rail underpass project was well underway by this time and was one of several key of projects across Melbourne to remove rail level crossings. These projects include Somerton Road rail overpass at an approximate cost of AU\$34 million ⁽³⁾ and Middleborough Road rail lowering costing around AU\$57 million ⁽⁴⁾.

The state of Victoria released the Victorian Transport Plan in December 2008 and is currently delivering this program. The AU\$38 billion plan aims to meet the growing transport demands in Victoria, shape a more productive state while providing a more liveable and sustainable future for its people. The plan focuses on six different areas including grade separations for railway level crossings. The government has committed around AU\$440 million to address congestion and safety in critical locations at rail level crossings. This paper presents some of the challenges faced on the Taylors roads rail underpass project, aiming to capitalise on key learnings on this type of project.

The paper focuses on two main elements of the works. The first is the relocation of services and challenges encountered while planning, assessing and relocating the services. This became a critical part of the project due to the limited alternatives for their relocation and the inherent risks in the physical relocation.

The second part of the paper focuses on the pivotal element of the project, which was the construction and jacking of the rail bridge. This challenge was compounded by the services that still needed to be relocated whilst minimising disruption to more than 200 daily train services. The technical aspects of these two parts are presented later in this paper.

2. SITE AND PROJECT DESCRIPTION

Taylor's Road is a major east-west arterial road carrying approximately 24,000 vehicles per day (vpd) in Melbourne's north-west suburbs. The crossing of the Melbourne-Bendigo & Sydenham rail line at Taylor's Road was originally a five-leg roundabout, experiencing delays to road traffic of approximately 20 minutes every hour in morning and afternoon peak times whilst trains were crossing. Taylor's road also serves as a main utility services corridor. The photo below shows an aerial view of the project area.



Photo 1 Taylor's Road - Aerial photo

The project involved the elimination of the roundabout and construction of a new road underpass with three lanes each way beneath the rural-metropolitan rail lines. In addition, it included the lowering of East Esplanade to Taylor's Road at a new signalised T intersection in order to maintain access to the Keilor Plains train station, the elimination of the Kerrison Avenue roundabout by the installation of a new set of traffic lights and the truncation of Sydenham Road. In order to maintain access for all residents, new service roads were constructed on Taylor's Road, East Esplanade and Regan Street. Figure 1 shows the alignment plan for these works.

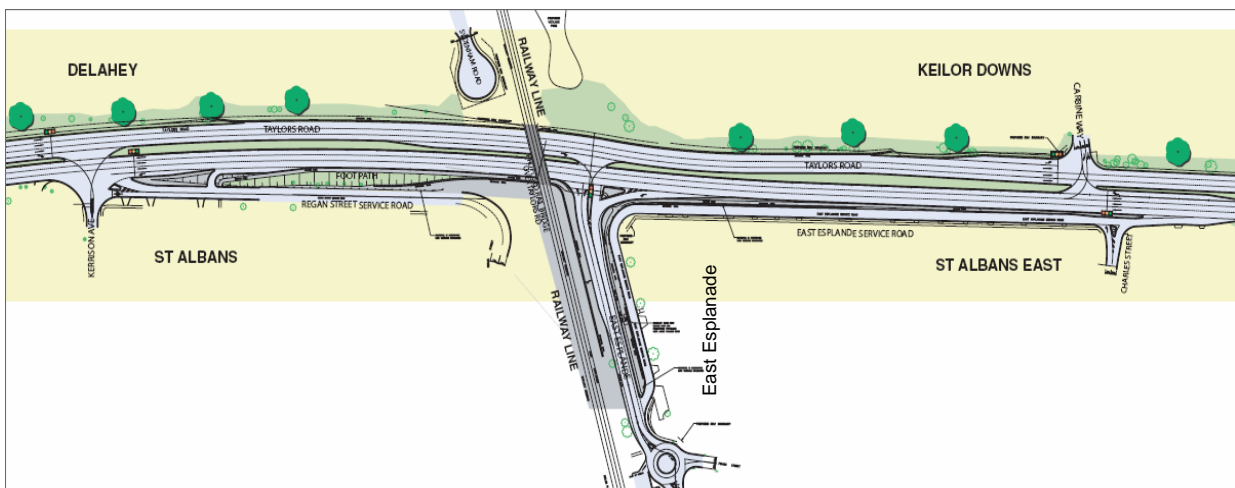


Figure 1. Alignment plan

3. TECHNICAL CHALLENGES & INNOVATIONS

During the preconstruction and construction stages of this project, several challenges arose. These are discussed under two headings below, which are relocation of services and construction and jacking of the bridge.

3.1. Relocation of Services

Taylor's Road is a main corridor for services in the outer western suburbs of Melbourne. The wide road reservation provides enough width to accommodate a large number of essential services without major conflict points. It also provides a suitable crossing point of the railway line for those services. The approved scope of the project included taking the road under the railway line, therefore necessitating the relocation of twelve assets.

A decision was made to undertake a number of service relocations before the main contract was awarded. Services in critical locations were relocated before the main contract in order to reduce the risk associated with approvals, cost and time during the main contract. The main advantages of this strategy was clear the work/excavation area as much as possible and reduce negotiation/approvals time with each utility company for the main contractor. The services that could not be relocated until the main contract was awarded had designs completed by VicRoads, which were approved by the utility companies.

Table 1 presents a summary of gas, electricity and telecommunications assets that existed in the area. It also includes the new asset's length and an assessment of how critical the asset's location was with respect to the excavation works. The last column contains details of the relocation strategy. These involved either design & construct the relocation of the asset before the main contract or VicRoads undertaking the design and supplying the information to the main contractor for the relocation to take place during the main contract.

Table 1 Summary of Gas, Electricity and Telecommunications assets

[Abbreviations: **HP**: High Pressure - **U/G**: Under Ground – **O/H**: Over Head – **D**: Design - **C**: Construct]

Service Type - Code	Description	Existing asset length	New asset length	Critical Location	Works 'before' or 'during' the main contract
Gas – G1	200mm HP U/G	400m	600m / bore under railway line	yes	D&C before
Electricity - E1	22Kv U/G	150m	600m / divide existing easement	yes	D&C before
E2	66Kv O/H	200m / 3 poles	900m / over head crossing of the railway line	yes	D&C before
E3	66Kv & 22Kv U/G	60m	160m	no	C during
E4	Low Voltage	Single pole	Single pole	no	C during
E5	Low Voltage	Single pole	Single pole	no	C during
Telecommunications - T1	12 -100mm diam PVC conduits - Optic Fibre / 64 pair copper trunk	900m	1800m	yes	D before C during

Figure 2 shows the original locations of assets (solid lines) and the new alignments (dashed lines). It is important to note that several options were investigated before agreement at the new alignment was reached with each utility company. In some instances, issues such as type of assets and minimum clearances to other services played a role in deciding where and how to accommodate these services.

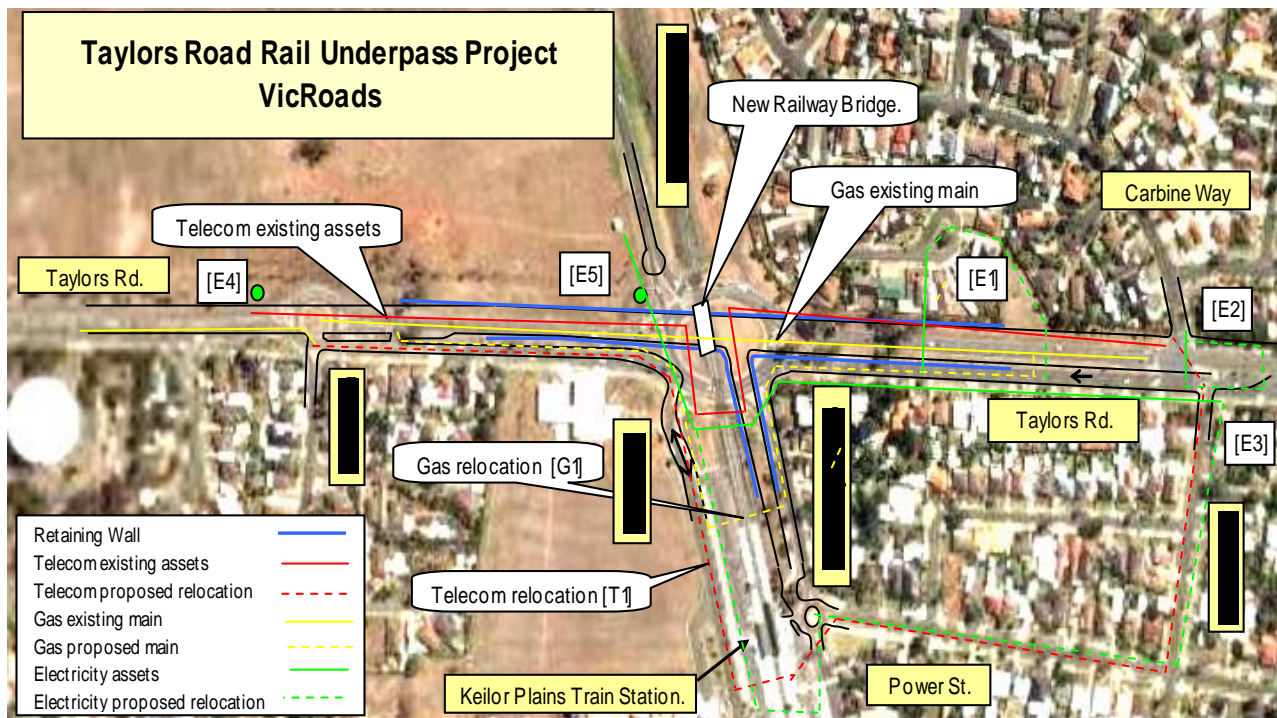


Figure 2. Gas, Electricity and Telecommunication assets. Original location and proposed relocation

A short description of the relocation of each service including the durations and challenges are provided below:

Gas relocation (3 months) – G1

In general terms, this service relocation was a small operation. The main challenge was to bore under the railway line for the first time on this project which outlined the protocol and set the standard for all subsequent service crossing bores of the railway line. The crossing had to be encased in order to satisfy rail requirements. A 400mm encase was bored in two days to accommodate the 200mHP gas main. In summary, it was a good learning exercise for the additional three bores to be undertaken before the main contract and two additional bores during the contract.

Electricity assets. (Approximately 2 years from E1 to E5)

The most critical electrical asset was the 22Kv U/G line [E1]. It crossed Taylors Road in the area of the cut and continued between houses on an existing easement. The challenges included finding the best relocation route, crossing existing assets, negotiations with water authorities in order to share an existing easement and dealing closely with the property owner affected by the easement.

The 66Kv O/H line [E2] ran parallel to the Taylors Road crossing over the railway line close to the roundabout. It could have remained at the same location, however during the two year construction period one pole would have been critically exposed to traffic and construction equipment. The electricity company did not accept that level of risk and hence this pole was relocated.

The third relocation was at the intersection of Carbine Way and Taylors Road where a 66Kv & 22Kv U/G lines [E3] crossed Taylors Road. The main issue was that a split point would end up under the road due to widening works in that area. The electricity company did not accept this arrangement and hence this split point was relocated

The 4th and 5th [E4 & E5] relocations were single electricity poles that were in close proximity to the new alignment. It was decided to leave the last three relocations [E3 to E5] to be carried out under the main contract in case the alignment could be re-designed and the relocations not be required.

Telecommunications assets [T1] (6 months)

These assets were optic fibre and copper lines that travelled east–west along Taylors Road. VicRoads commissioned the detailed design for the relocation works. The telecommunications company then undertook the relocation of their own assets during the main contract. The challenge was to coordinate civil and service relocation works due to the constrained works area and critical milestone dates to move the bridge.

Water assets

Table 2 presents a summary of water assets that existed in the area. It provides the same details as included in Table 1.

Table 2 Summary of Water assets.

[Abbreviations– **CWW**: City West Water – **MW**: Melbourne Water - **D**: Design - **C**: Construct]

Service Type -Code	Description	Existing asset length	New asset length	Critical Location	Works 'before' or 'during' the main contract
Water W1	CWW 600mm	700m	1000m	Yes	D&C before
W2	CWW 900mm	150m	150m	Yes	D&C before
W3	CWW 300mm	Cross connection	Cross connection	Yes	D&C before
W4	MW 900mm	500m	550m	Yes	D before C during
W5	MW 1350mm	500m	550m	Yes	D before C during

Figure 3 shows the original locations of the water assets and the new alignments. Three of the water mains (300/600/900mm) were City West Water (CWW) assets. The other two mains (900/1350mm) were Melbourne Water (MW) assets.

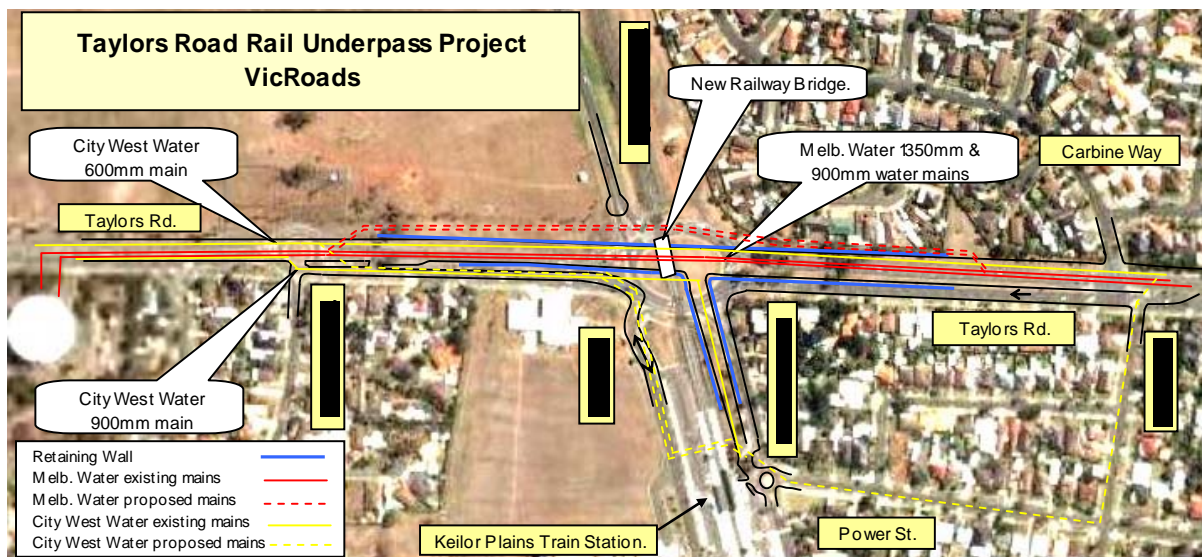


Figure 3. Water assets. Original location and proposed relocation

The detailed design for all five water mains was undertaken in a six week period. Weekly design coordination meetings with the two utility owners (MW and CWW) were run in order to accelerate the detailed design. VicRoads directly managed the CWW relocation works whilst MW relocations were undertaken during the main contract. The reason for this was the high risk in relocating the two MW water mains without a detailed design for the road, railway bridge and especially the northern retaining wall and also timing available for shutdown of the mains.

VicRoads engaged a contractor directly for the relocation of the CWW assets. The works started in November 2006 and the main challenge was the two bores under the railway station to cross the railway line. The rail crossing works commenced mid January 2007. Figure 4 below shows the approved design for the two encased bores under the railway station and photo 2 shows the encased pipe.

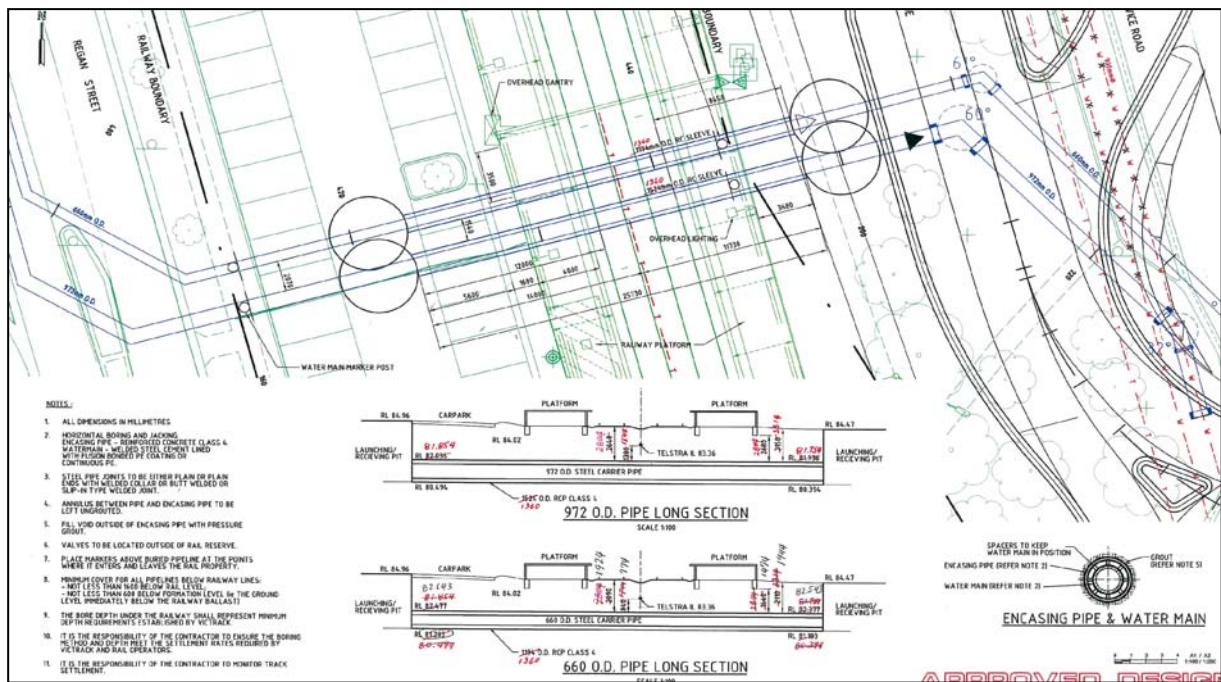


Figure 4. Layout and cross sections of CWW crossing under railway station



Photo 2 Encased Pipe

One of the challenges faced with the bore works were issues related to the water and air supply. The boring also encountered the transition between hard clay and hard rock about 10m into the first bore. The bore came to a stop when one of the two collapsible bore heads broke as detailed in photo 3. The whole bore unit had to be retrieved and taken for major repairs. The final challenge was to finish the bore without breaking the bore head again, which meant the bolts of the drive assembly having to be monitored and replaced routinely.



Photo 3 Collapsible bore head broken

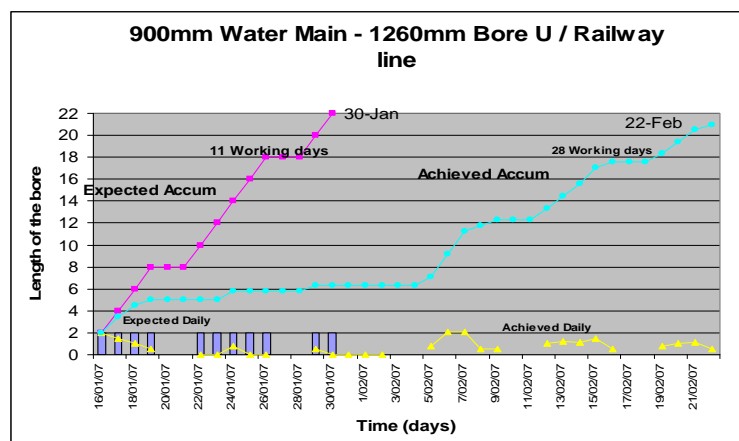


Figure 5 Expected vs. achieved graph.

Figure 5 shows the expected versus achieved program for the bore works. The bore works were expected to take only eleven days but it took a total of 28 days, almost triple the programmed period.

3.2 Construction and jacking of the rail bridge

The primary focus of this project was to remove the rail level crossing. The design and construction methodology of the bridge played a vital role in achieving one of the main aims of the project which was to minimise disruption to the rail services during construction.

Bridge Design

The railway bridge consisted of a single span trough girder structure which was cast-in-situ and then post-tensioned. Figure 6 shows the layout of the post tensioning tendons and figure 7 shows an isometric representation of the bridge shape. This section was chosen to minimise structural depth below the rail tracks which in turn optimised the grade line, hence reducing the amount of excavation.

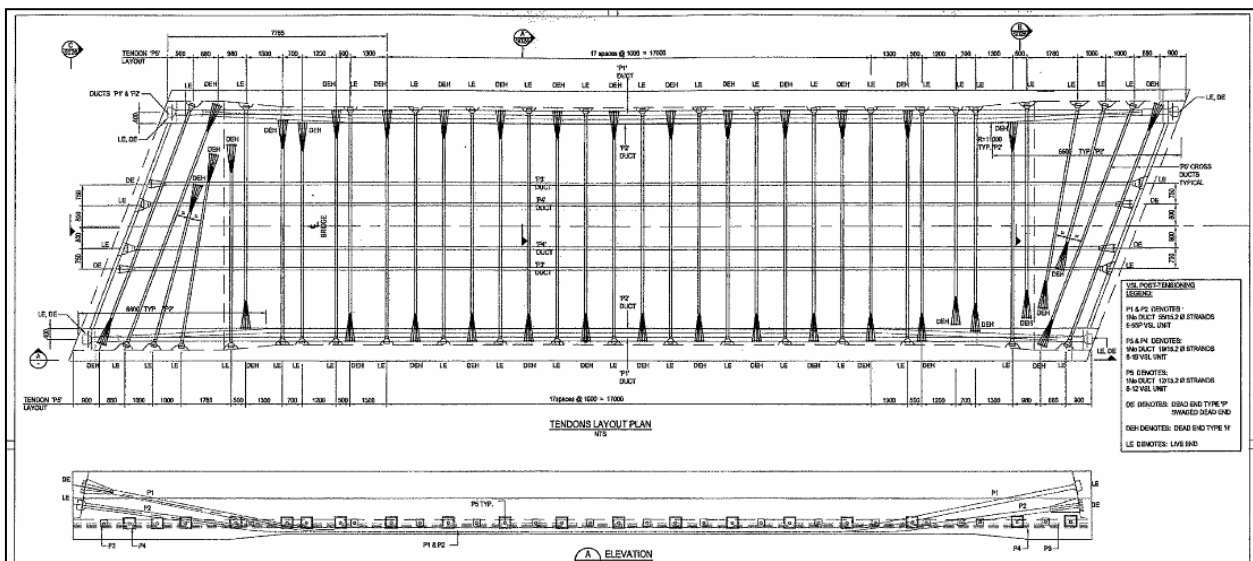


Figure 6 Layout post tensioning tendons plan of the railway bridge

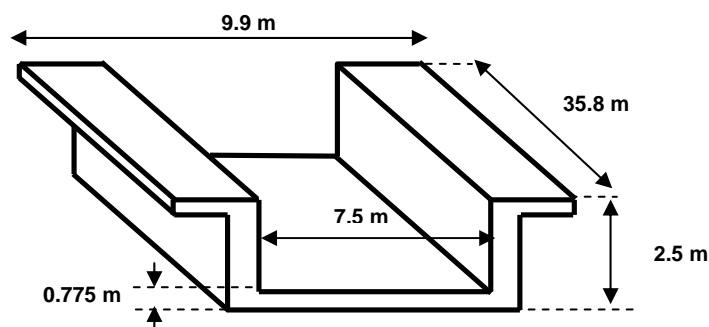


Figure 7 Isometric representation of the railway bridge

Bridge Construction

The bridge was built east of the existing railway line in the centre of the original roundabout. The eastbound traffic was transferred to the south side of Taylors Road, on the newly constructed service road in order to create the work area required for the construction of the bridge. A requirement of the contract was to maintain two lanes of traffic each way at all times in order to reduce the impact of the works on the local road network and to ensure the railway crossing was always operational.

After widening works to achieve four lanes were completed, the traffic was switched south of the roundabout in June 2007 as shown in photo 4. This arrangement remained in that position until the railway bridge was constructed, jacked into position and the road underneath the bridge completed which was a period of approximately 18 months.



Photo 4 Traffic switched south of the previous roundabout & bridge under construction

With the roundabout clear of vehicles, the construction of the bridge could begin. The location was carefully planned in order to avoid the utility services buried underground near the bridge construction area. The first task was to excavate the work zone to allow the bridge to be built at the level of the existing rail line whilst avoiding these services. Two parallel concrete jacking beams were built on which the bridge would be constructed. Those beams were constructed to a distance of 2.4m from the fully operational railway line, which was the minimum distance required by the rail authorities for construction without affecting rail services. These beams were extended during the full weekend occupation using steel I sections to jack the bridge directly onto the rail alignment at the right level.

The second major operation that occurred concurrently was to construct four 13.5m long bored piles in the final bridge location. These works had to be undertaken at night under rail occupations. The working window was from 11.30pm until 4.30am in order to minimise the impact on rail services which was based on the last train passing at 10.45pm and the first train passing at 5.30am. The works had to be programmed and coordinated to maximise the use of this working window.

A total of twenty night occupations were used to temporarily relocate railway signals, signalling control equipment, communications cabling, fibre optics, electricity lines as well as drilling and casting of the bored piles. Photo 5 shows night works for piles installation.

The bridge was constructed in two stages with the bottom slab being cast first and then the two vertical webs last. The approximate volume of concrete was 375m³ with a total weight of 1200 tonnes. The post-tensioning took place before the railway tracks and ballast was placed on the bridge deck at the right levels to facilitate the connection to the rail tracks off the structure after the bridge was positioned. See photo 6 showing the completed rail bridge including the rail tracks.



Photo 5 Night bore works



Photo 6 Rail Bridge completed sitting east of the railway line

Jacking of the bridge and related works

A 56 hour full weekend occupation of the rail line was programmed between 8pm Friday 27 October and 4.30am Monday 30 October 2007 to jack the bridge into its final position. This would be the only time when rail services were significantly disrupted during the project. Replacement bus services were provided during this weekend to transport all rail passengers around this site. A construction program was prepared detailing activities, crews and resources in one hour intervals to allow accurate tracking of the progress of works against program.

During the week prior to the occupation, the bridge was lifted around 200mm using the four vertical hydraulic jacks as shown in photo 7. Then a trial run with the 2 x 600 tonne horizontal hydraulic jacks was undertaken in order to ensure the reliability of the horizontal jacking system as depicted in photo 8. Additionally, the four bored piles had their pile caps cast to the right level for the rail bridge to be placed in its final position.



Photo 7 Vertical Hydraulic jack



Photo 8 Horizontal Hydraulic Jack

The works began on the Friday night around 8.30pm after power to the overhead lines was switched off. The first task was to cut the existing railway tracks and remove them to enable the excavation equipment to remove the remaining railway embankment for the bridge.

After excavation was completed, the next task was to place steel beams horizontally at the ends of the two concrete beams, which enabled the bridge to be jacked into its final position as shown in photos 9 and 10. Note the transition between the concrete and the steel beams. At around 6pm on the Saturday night, the bridge was ready to be jacked into position.



Photo 9 Steel beam being placed



Photo 10 Steel beam placed

The process started with the horizontal hydraulic jacks moving the bridge approximately 3m lengths at a time. Then the jacks had to be released from their jacking anchor points, retracted and moved to the

next set up point, re-anchored and ready to start the process again. It took approximately five re-settings of the jacks for the bridge to reach its final position on top of the pile caps. Each stroke took approximately 20 minutes in jacking and 40 minutes in resetting.

By midnight on the Saturday night the bridge had reached its final position and by 2am Sunday morning it was carefully lowered onto the pot-bearings, grouted and secured in place. See photo 11 showing the bridge on its final position ready to be grouted.



Photo 11 Bridge on its final position

The next task was to place the bridge approach slabs into position. They were manufactured in two halves for each end of the bridge, with each half weighing approximately 14 tonnes. This design allowed for manoeuvring the slabs into position using a crane whilst avoiding the overhead power lines. Photo 12 shows the close proximity to the power lines during this operation. This task proved more difficult than anticipated, not only because of the overhead power lines but also due to the strong winds that started to affect the operation. Photo 13 shows the placement of the last half of the approach slabs by around 5.30am on Sunday morning



Photo 12 Approach Slab over the lines

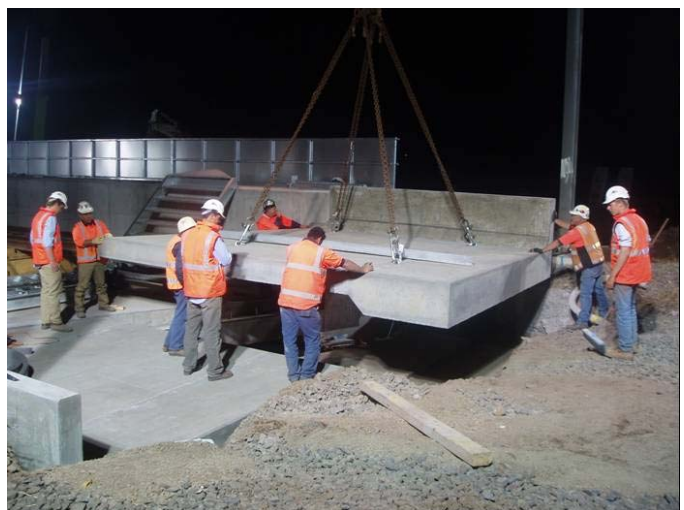


Photo 13 Approach slab being placed

After the approach slabs were successfully placed in position, the next task was to install the missing sections of track connecting the cut off points and the section of track already in place on the bridge deck. Photo 14 shows the installation of one of the panels. Photo 15 shows the track welding works using a disposable capsule on the track, Note also the tamper attachment on the excavator in the background which has two rail axles (end & back) for easy manoeuvring on the tracks.



Photo 14 Track installation



Photo 15 Track Welding and tamping operation

The final works were to install, re-commission and test the railway signals, signalling control equipment, communications cabling, fibre optic, low voltage and high voltage lines which were placed in conduits under the maintenance platform attached on the side of the bridge.

The works were completed on time and enabled the first train at 5.30am on Monday morning to travel across the railway bridge achieving a major milestone for the project.

3.3 Completion of the project.

Excavation

Excavation under the new railway bridge continued at the same time as the construction of the retaining walls. The excavation went down 2 metres before the first 'lift' of the shotcrete walls was undertaken. Another 2 m was then excavated and a second 'lift' of the wall was completed. The deepest part of the excavation at the bottom of the underpass was around 6 metres for a short length thus completing the northern retaining wall as shown on photo 16. Photo 17 shows the excavation works and also partial construction of the south east and south west retaining walls.



Photo 16 Overall excavation



Photo 17 Excavation around the bridge area

Traffic transfer sequence

The construction of the south east and south west retaining walls were also proceeding but could not be completed until traffic was transferred under the bridge onto the new road in order to allow the excavation of East Esplanade. Traffic was transferred under the bridge in two stages. Firstly the eastbound carriageway was completed and eastbound traffic was transferred allowing additional work area to complete the excavation and further construction of the south east and south west retaining walls. This arrangement is shown in photo 18 which also shows pavement construction advancing on the other carriageway.

Westbound traffic was then transferred under the bridge onto the new road which enabled East Esplanade to be closed and allow the completion of the excavation and the finalising of the construction of the south east and south west retaining walls. This arrangement is shown in photo 19 looking west. Note that only two lanes of traffic in each direction were provided in order to maintain adequate access to the site using the third lane.



Photo 18 Opening to Eastbound traffic only



Photo 19 Opening to Westbound traffic

Final stage and opening

The final section of excavation on East Esplanade and completion of the SE & SW retaining walls was undertaken as the final stage of the project. Photo 20 shows the excavation works on the East Esplanade area. Access to residents along Taylors Road and East Esplanade was maintained with the use of service roads. Photo 21 shows the completed project. Note the architectural treatment on the retaining walls and the rail bridge cladding. The project was finally open to the public by the Victorian Minister for Roads and Ports in November 2008, two months ahead of schedule and with minimal disruption to rail services and road users.



Photo 20 East Esplanade Excavation



Photo 21 Project Completed

4. SUMMARY

The Taylors Road project presented a number of challenges and a range of solutions were used to overcome these issues. The following points highlight the main aspects of the project:

- A complex project due to the number of services in the area, the railway crossing and the ongoing challenge of maintaining traffic along Taylors Road at all times with minimal disruption to train services.
- Effective and efficient project management by VicRoads, coordinating efforts amongst all parties involved with the focus on delivering a key project to decongest a main arterial road and provide safety for road and rail users.
- Risk assessment and cost benefit analysis lead to additional service relocation works undertaken by VicRoads during early stages of the project, prior to the main contract. There was a level of risk in VicRoads managing these works as it involved areas outside VicRoads normal expertise. However, the benefits in completing these works outweighed this risk.
- VicRoads clear commitment to deliver this project with minimal disruption to road users and rail services proved to be a challenge that was overcome using a mix of traditional contract delivery mechanism such as "Design & Construct" and "Construct only".
- VicRoads' open approach to a variety of challenges and its capacity to assess, adapt and provide the most appropriate solution in particular circumstances.
- VicRoads ability to bring together several stakeholders' interests, interpret their needs and provide satisfactory solutions that allowed the successful delivery of a key project for the western suburbs of Melbourne.
- Commitment between VicRoads and the Contractor to undertake a high risk project in a united and collaborative manner that would benefit both parties.

5. CONCLUSION

The Victorian Government is committed to address the transport challenges that are currently facing Melbourne and regional Victoria. The Victorian Transport Plan is investing AU\$38 billion in six specific areas that will deliver a more efficient transport system for the city and the State. The range of projects varies from small duplications in suburban areas to major upgrades of infrastructure in rail, tram, bus, bicycle and road networks.

Taylors Road is yet another piece of the puzzle that has improved a major east west road corridor in the western suburbs of Melbourne. This type of medium size project and in particular the removal of another "railway level crossings" is a key priority in order to decrease traffic congestion in particular areas, provide safer crossings of railway lines for vehicles and pedestrians and a safer and more reliable rail network.

The Taylors Road rail underpass project was successfully delivered two months ahead of schedule and with minimal disruption to rail services and road users. VicRoads' commitment to deliver the project in the most efficient way, with the best possible mix of technical solutions, and using an open managerial approach has benefited the community in the short, medium and long term and could be used as a model for future similar rail level crossing upgrades.

REFERENCES

- (1) Department of Transport, Public Transport, Railway Crossings, (2008, May 12) (web page last reviewed: 2009, May 6) <http://www.transport.vic.gov.au/DOI/Internet/transport.nsf/AllDocs/>
- (2) Department of Transport, Public Transport, Railway Crossings, (2009, April 25) (web page last reviewed: 2009, May 6) <http://www.transport.vic.gov.au/DOI/Internet/transport.nsf/AllDocs/>
- (3) VicRoads, web page last reviewed: 2008, Feb 11 <http://www.vicroads.vic.gov.au/Home/RoadsAndProjects/RoadProjects/NothernSuburbs/SomertonRoadDuplicationProject>.
- (4) VicRoads, web page last reviewed: 2008, July <http://www.vicroads.vic.gov.au/Home/RoadsAndProjects/RoadProjects/CompletedRoadsProjects/MiddleboroughRoadRailSeparationProject>.